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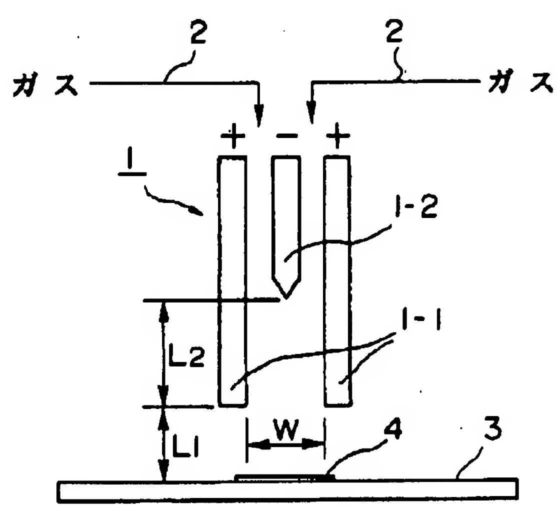
(54)【発明の名称】　直流アーク放電プラズマによる表面処理方法

(57)【要約】
【課題】　基板上の目的とする領域のみに処理を施すことができる上、簡易な手段で処理面積の大面積化にも十分に対応できるアーク放電プラズマによる表面処理方法の提案。
【解決手段】　２つの電極間に放電用および処理用ガスを供給し直流電圧を印加することにより該電極間に発生するアーク放電によるプラズマを用いて表面処理する方法であって、固定された基板に対して前記プラズマ発生源を移動させる方式、または前記プラズマ発生源を固定し基板側を移動させる方式により表面処理することを特徴とする。



【特許請求の範囲】

【請求項１】　２つの電極間に放電用および処理用ガスを供給し直流電圧を印加することにより該電極間に発生するアーク放電によるプラズマを用いて表面処理する方法であって、固定された基板に対して前記プラズマ発生源を移動させる方式、または前記プラズマ発生源を固定し基板側を移動させる方式により表面処理することを特徴とする直流アーク放電プラズマによる表面処理方法。

【請求項２】　前記プラズマ発生源を複数並設して表面処理することを特徴とする請求項１記載の直流アーク放電プラズマによる表面処理方法。

【請求項３】　前記プラズマ発生源または基板をプログラム制御で移動させることを特徴とする請求項１または２記載の直流アーク放電プラズマによる表面処理方法。

【請求項４】　前記基板とプラズマ発生源との相対位置を変化させるか、または複数のプラズマ発生源のうちいずれかを選択して通電することにより、任意の領域を表面処理することを特徴とする請求項１乃至３のうちいずれか１項記載の直流アーク放電プラズマによる表面処理方法。

【請求項５】　前記放電用および処理用ガスとして、SiH_4、$SiCl_4$、SI_2Cl_6、CH_4、C_3H_8、TEGa、$TiCl_4$、NH_3、N_2、BF_3、O_2、CF_4、C_2F_6、$Cu(DPM)_2$、PH_3、C_3F_8、C_4F_8、F_2、NF_3、Ar、He等のガスを用いたことを特徴とする請求項１乃至４のうちいずれか１項記載の直流アーク放電プラズマによる表面処理方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、プラズマを用いた固体表面処理技術に係り、より詳しくは２つの電極間に直流電圧を印加することによるアーク放電プラズマにより表面処理する方法に関する。

【０００２】

【従来の技術】従来、プラズマを用いた固体表面処理技術（大面積アモルファスシリコン太陽電池の高速かつ連続製造技術等）としては、平行平板型の高周波グロー放電を用いたプラズマによる方法（プラズマＣＶＤ法）が採用されている。この方法は図９にその概要を示すごとく、真空排気可能な容器１１内に互いに対向設置した一対の平行平板型の電極１２、１３間に、処理用ガスおよびその他のガスとの混合ガスを供給し該電極間に電源１５にて高周波電圧を印加して電極間をプラズマ状態にすることにより、一部のガスを分解し、一方の電極１３に取付けた基板１６上に分解生成物を作用させて薄膜堆積、エッチング、表面改質等の効果を得る技術である。なお、１４は電源１５のインピーダンスとプラズマを伴った平行平板型の電極１２、１３のインピーダンスの整合を取るための整合器である。高周波電圧の周波数としては、１３．５６ＭＨｚが広く用いられている。

【０００３】上記のプラズマを用いた固体表面処理技術の特徴としては、以下に記載する３点があげられる。

①平行平板型の電極の面積を大きくすることにより容易に処理面積の大面積化が可能である。

②直流放電では基板や堆積物が絶縁物である場合に放電が維持されないのに対し、高周波では基板や堆積物の導電性に依存しないこと。

③高周波電圧の周波数をより高周波にするか、もしくはパルスにすることにより処理品質が向上する場合がある（例えばアモルファスシリコン太陽電池の場合には光電変換効率が向上する等）。

【０００４】

【発明が解決しようとする課題】しかし、上記した従来の高周波グロー放電によるプラズマＣＶＤ法では、処理面積の大面積化を進めると電極の一辺の長さが用いる高周波の波長と同じとなり、電極面内における電界分布に不均一が発生し均一な処理が不可能となり、小面積の場合と同じ品質を確保できないという問題があった。特にこの問題は、高品質化が可能なより高い周波数やパルスを用いた際に顕著となり、処理面積の増大化には限界があった。

【０００５】本発明は、このような従来の平行平板型の高周波グロー放電によるプラズマＣＶＤ法の大面積化における問題を解決するためになされたもので、基板上の目的とする領域のみに処理を施すことができる上、簡易な手段で処理面積の大面積化にも十分に対応できる直流アーク放電プラズマによる表面処理方法を提案しようとするものである。

【０００６】

【課題を解決するための手段】本発明に係る直流アーク放電プラズマによる表面処理方法は、２つの電極間に直流電圧を印加することにより電極間に発生するアーク放電によるプラズマを用いる方式であり、その要旨は２つの電極間に放電用および処理用ガスを供給し直流電圧を印加することにより該電極間に発生するアーク放電によるプラズマを用いて表面処理する方法であって、固定された基板に対して前記プラズマ発生源を移動させる方式、または前記プラズマ発生源を固定し基板側を移動させる方式により表面処理することを特徴とするものである。また、前記プラズマ発生源を複数並設して表面処理したり、前記プラズマ発生源または基板をプログラム制御で移動させたり、前記基板とプラズマ発生源との相対位置を変化させたり、あるいは複数のプラズマ発生源のうちいずれかを選択して通電したりするものである。なお、前記放電用および処理用ガスとしては、SiH_4、$SiCl_4$、Si_2Cl_6、CH_4、C_3H_8、TEGa、$TiCl_4$、NH_3、N_2、BF_3、O_2、CF_4、C_2F_6、B_2H_6、$Cu(DPM)_2$、PH_3、C_3F_8、C_4F_8、F_2、NF_3、Ar、He

等のガスを用いることができる。

【0007】本発明における電極構造は、中空円筒とその中心軸とをそれぞれ電極とするのが好ましく、その円筒直径は1cm以下が好ましい。この導電性の中空円筒とその中心軸との間に直流電圧を印加し、円筒内に処理用ガスまたは他のガスとの混合ガスを導入することにより、電極間にアーク放電によるプラズマが発生し、処理用ガスが分解されてその分解生成物が円筒の開口端より吹き出し、開口端と対向する基板に薄膜堆積、エッチング、表面改質等の作用をおよぼす。また、平行平板型の直流放電では基板が絶縁性であると放電が維持されないが、本発明では処理される基板に対して電極が独立しており、基板の導電率依存性はない。

【0008】

【発明の実施の形態】図1は本発明に係る直流アーク放電プラズマによる表面処理方法の基本構成を示す概略図、図2は本発明法における電極構造を例示したもので、（a）は陽極と陰極を対向配置させた電極を示す概略図、（b）は陰極と円筒形の陽極とを組合せた電極を示す概略図、（c）は（b）に示す構造の電極を複数配置して構成した電極を示す、（d）は陰極と多段の円筒形陽極とからなる電極を示す概略図、（e）は陽極と陰極を対向配置させた電極を多段に配置して構成した電極を示す概略図、図3はフレキシブルポリマー基板に対する表面処理方法の一例を示す概略図、図4はシート状の基板上に広幅の表面処理を施す方法の一例を示す概略図、図5は図2（c）に示す複数配置構成の電極を間隔配置して三層の薄膜を連続して作成する方法の一例を示す概略図、図6は基板上の任意の領域に表面処理を施す方法の一例を示す概略図、図7（a）（b）はそれぞれ基板上に微結晶薄膜を作成する方法を例示した概略図、図8はフレキシブルポリマー基板上に太陽電池を形成する方法の一例を示す概略図であり、1は電極、1－1は陽極、1－2は陰極、2は放電用および処理用ガス、3は基板、4は領域、Wはノズルの開口径、L_1 はノズル先端と基板との距離、L_2 は陰極の先端と陽極先端との距離、3－1はフレキシブルポリマー基板、3－2はシート状の基板である。

【0009】図1において、陽極1－1と陰極1－2間の間隙に放電用および処理用ガス2を供給すると、基板3の領域4に処理用ガスの性質によって決まる処理が施される。この場合、領域4の直径はノズルの開口径Wと、ノズル先端と基板との距離L_1 によって決まる。また、陰極の先端と陽極先端との距離L_2 は、領域4へのプラズマ照射に伴う加熱の効果を制御する際に変化させる。この距離L_2 を大きくすると加熱効果が抑制され、小さくすると加熱効果が促進される。すなわち、電極電圧として直流を用いた微小プラズマ源を用いると、基板上の目的とする領域に処理を施すことができる。

【0010】次に、図2（a）は電極を横配置した例で、陽極1－1と陰極1－2を対向配置して構成した電極1に高電圧を印加し、その片方の端面から陽極1－1と陰極1－2間の間隙にArガスを流してプラズマ状態にし、プラズマ中の反応活性な化学種をもう片方の端面のノズルから基板3に照射することにより、基板3上のプラズマ照射部のみの表面改質を行うことができる。

（b）は電極を縦配置した例で、陰極1－2と中空円筒形の陽極1－1´に高電圧を印加し、陰極1－2と中空円筒形の陽極1－1´との間隙に、例えばCF_4、C_3F_8、C_2F_6、C_4F_8、F_2、NF_3等を流してプラズマ状態にし、反応活性な化学種を中空円筒の出口から例えばSi基板3上に照射することにより、Si基盤3上のプラズマ照射部のみをエッチングすることができる。また（c）に示すように、複数の電極1を一列に連ね、O_2を放電ガスとして用いることにより、対向する基板3上に線状処理を施すことができる。さらに、（d）のように陰極1－2と多段の中空円筒形陽極1－1´とからなる電極1を用いた場合、あるいは（e）のように陽極1－1と陰極（1－2）を対向配置させた電極1を多段に配置して構成した場合には、各段のバイアス電圧を制御することにより、出口から放出されるプラズマの形状を制御し処理を施す基板3表面にプラズマが直接さらされる程度の制御を行うことができる。

【0011】図3はロールRで搬送されるフレキシブルポリマー基板3－1に対して、図2（c）に示す構造の電極1を用い、Arプラズマを照射することにより、ロールに巻かれたフレキシブルポリマー基板3－1の表面を所定の幅にわたって連続して表面改質することができる。

【0012】図4はシート状の基板3－2に連続して薄膜堆積等の表面処理を施す方法を例示したもので、この場合は基板3－2の上方に電極1を一列に並設し、基板3－2を前記電極列と直角な方向に移動させることにより、該基板3－2上にとぎれることなく連続して薄膜堆積等の表面処理を施すことができる。この場合、電極1の電子密度を従来の平行平板型プラズマ源より高密度プラズマとすることができるので、高い処理速度が得られる。さらに、従来の高周波を用いるプラズマ源では、電極の一列の長さが長くなると波長の影響により列内で不均一が生じるが、直流放電を用いる本発明ではその影響が全くない。

【0013】図5はロールRで搬送されるフレキシブルポリマー基板3－1の上方に多層膜を成膜する方法を例示したもので、この場合は図4に示す一列に並設した電極1を搬送方向に所望の間隔を置いて例えば3列設置し、それぞれの電極列にSiH_4／PH_3混合気体、SiH_4、SiH_4／B_2H_6混合気体を用いたプラズマを発生させることにより、p型、i型、n型の三層のSi薄膜構造をとぎれることなく連続して成膜することができる。

【００１４】図6は単一電極による任意形状領域の処理方法を例示したもので、電極１および基板３はそれぞれ水平移動機構および垂直移動機構により、幅方向、長さ方向および高さ方向に移動可能となっている。したがって、この方式の場合は電極１および基板３の水平移動機構により基板３上の任意の領域に表面処理を施すことができる。また、電極１および基板３の垂直移動機構により表面処理の程度、すなわち薄膜であれば堆積速度または膜厚を、エッチングであればエッチングレートまたはエッチング深さを制御することができる。この方法における電極および基板はプログラム制御により移動させる。

【００１５】図7（ａ）（ｂ）はそれぞれ図２（ａ）（ｂ）に示す電極を用い、放電ガスH_2に対して反応性ガスSiH_4またはSiF_4を導入し、プラズマ中で生成された原子状Hによって反応性ガスを分解し、多量のHラジカルの寄与により３００℃以下の低温で微結晶Ｓｉ薄膜をシート状の基板３－２上に堆積させる方法である。この方法によれば、４００℃以上の基板温度を用いることにより多結晶シリコン薄膜を体積させることができる。また、４００℃以上の超耐熱性を有するフレキシブルポリマー基板を用い、連続成膜方式を用いることによりフレキシブルポリマー基板上に多結晶シリコン薄膜を連続で大面積成膜できる。

【００１６】また、図8に示すごとく上記フレキシブルポリマー基板３－１上への多結晶シリコンを用いたｐ層、ｉ層、ｎ層の連続堆積に、透明電極形成過程、金属電極形成過程、ラミネート加工工程を加えることにより、フレキシブルポリマー基板３－１上に多結晶シリコン太陽電池を高効率で形成することができる。

【００１７】この他、以下に記載する処理を施すことが可能である。

（１）プラズマ源にガスとして$TiCl_4$とN_2やNH_3を用い、プラズマ源自身および照射する対象をコンピュータ制御によりＸ、Ｙ、Ｘ軸制御することにより、任意形状の対象に対してＴｉＮコーティングを施す。

（２）トレイに並べた多数の切削バイトに対し、ガスとしてH_2希釈のCH_4を用いることにより、ダイヤモンドコーティングを連続して大量処理する。

（３）電極を２列配列し、前列にＡｒやＨｅのプラズマ源を設け、基板表面の密着性を向上させ、後列に原料として$Cu(DPM)_2$等のＣｕ含有ガス原料を用いた銅薄膜形成プラズマを設けることにより、密着性の高いプリント基板を大面積、高速、連続で形成する。

（４）電極と中空の円筒を交互に円柱状に束ね、中空円筒にはＴＥＧａを流し、放電円筒にはN_2を流すことにより、高密度N_2プラズマ中で生成されたＮ原子がＴＥＧａと反応し基板上にＧａＮを形成する。また、大気圧放電が可能であるため、成長スピードが早いことが期待され、バルク成長も可能と予測される。

（５）（４）において、すべてを放電円筒とし、放電ガスとして$SiCl_4$、Si_2Cl_6等のＳｉ含有ガスと、CH_4やC_3H_8等のＣ含有ガスを用いる円筒を交互に円柱状に束ねることにより、基板上にＳｉＣを成長させる。

【００１８】

【発明の効果】以上説明したごとく、本発明によれば、２つの電極間に直流電圧を印加することにより電極間に発生するアーク放電によるプラズマを用いたことにより、電子密度の向上により従来の平行平板型の直流放電方式に比べ高い処理速度が得られ、また薄膜堆積の場合には、成膜を行う容器内の不純物が膜中に混入するスピードに対して成膜元素の堆積スピードが相対的に向上するため、最終的に得られる薄膜内での不純物密度が低減され、品質向上がはかられる。さらに、多数の円筒形電極を連続して並べることにより、大面積化処理を容易に行うことができるとともに、高品質の大面積成膜を確保することができる。またこのときも、高周波を用いると前記円筒列の長さが波長に近づくと平行平板と同様の影響が現れるのに対し、直流を用いたことによりその影響を回避できる。また、本発明法では大面積化と同時に基板とノズルとの相対位置を変化させたり、ノズルをＯＮ、ＯＦＦ制御したりすることにより任意の領域に薄膜堆積が可能となる。

【図面の簡単な説明】

【図１】本発明に係る直流アーク放電プラズマによる表面処理方法の基本構成を示す概略図である。

【図２】本発明法における電極構造を例示したもので、（ａ）は陽極と陰極を対向配置させた電極を示す概略図、（ｂ）は陰極と円筒形の陽極とを組合せた電極を示す概略図、（ｃ）は（ｂ）に示す構造の電極を複数配置して構成した電極を示す概略図、（ｄ）は陰極と多段の円筒形陽極とからなる電極を示す概略図、（ｅ）は陽極と陰極を対向配置させた電極を多段に配置して構成した電極を示す概略図である。

【図３】フレキシブルポリマー基板に対する表面処理方法の一例を示す概略図である。

【図４】シート状の基板上に広幅の表面処理を施す方法の一例を示す概略図である。

【図５】図２（ｃ）に示す複数配置構成の電極を間隔配置して三層の薄膜を連続して作成する方法の一例を示す概略図である。

【図６】基板上の任意の領域に表面処理を施す方法の一例を示す概略図である。

【図７】基板上に微結晶薄膜を作成する方法を例示したもので、（ａ）は図２（ａ）に示す電極を用いた場合の概略図、（ｂ）は図２（ｂ）に示す電極を用いた場合の概略図である。

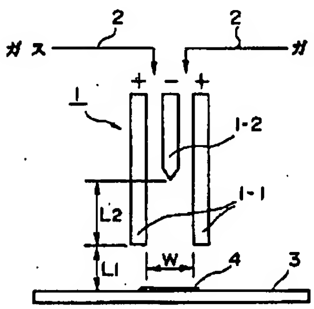
【図８】フレキシブルポリマー基板上に太陽電池を形成する方法の一例を示す概略図である。

【図9】平行平板型の高周波グロー放電を用いたプラズマによる従来の方法（プラズマCVD法）を示す概略図である。

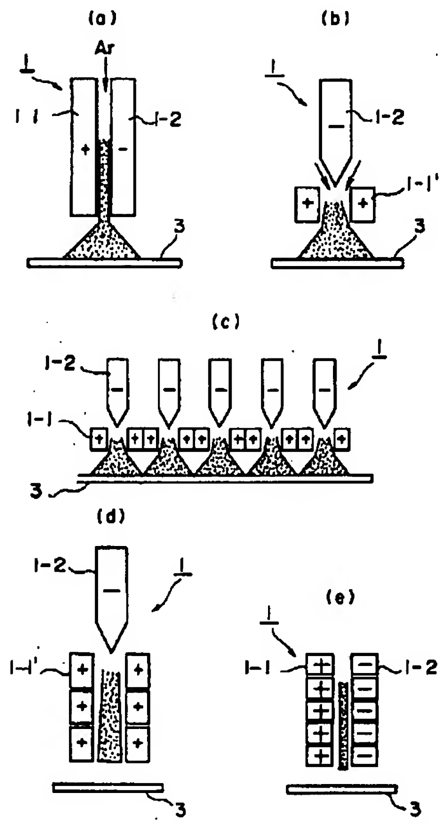
【符号の説明】

1　電極
1－1　陽極
1－2　陰極
2　放電用および処理用ガス
3　基板
4　領域
W　ノズルの開口径
L1　ノズル先端と基板との距離
L2　陰極の先端と陽極先端との距離
3－1　フレキシブルポリマー基板
3－2　シート状の基板

【図1】



【図2】



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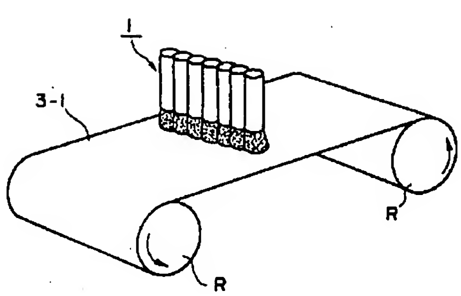
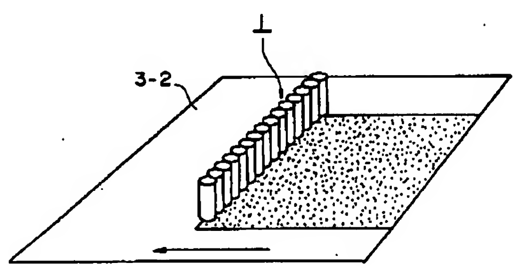
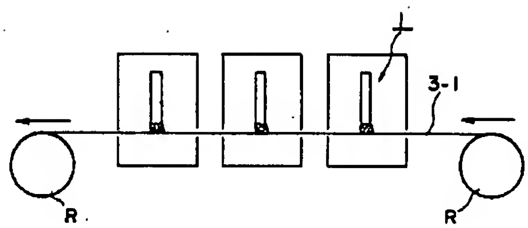


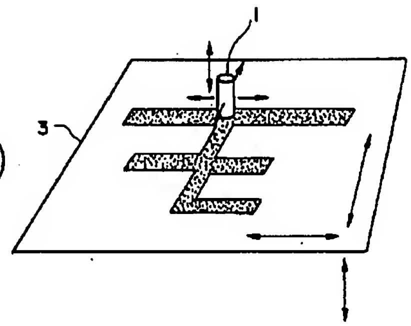
【図4】



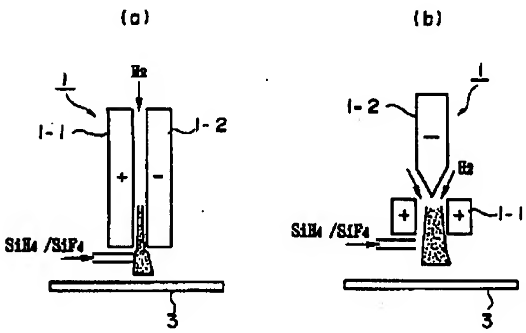
【図5】



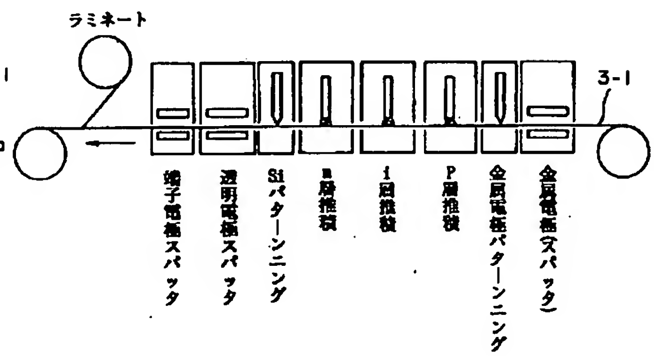
【図6】



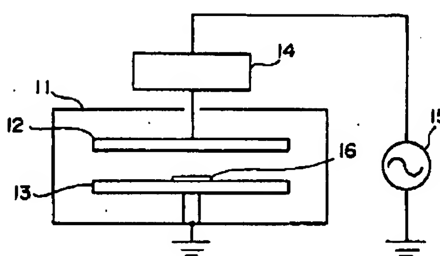
【図7】



【図8】



【図9】



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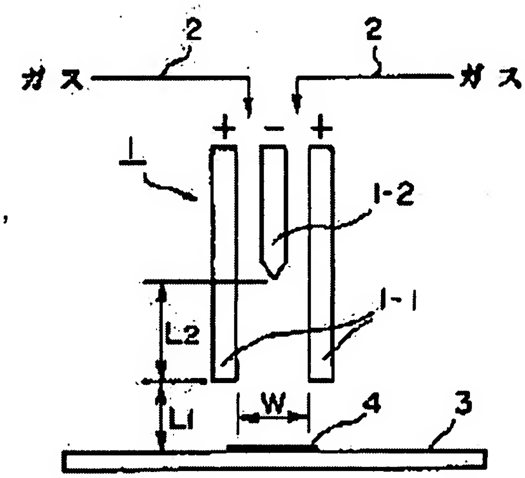
(72)Inventor : OKUI TOKUJIRO

(54) SURFACE TREATMENT METHOD BY DC ARC DISCHARGE PLASMA

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a surface treatment method of arc discharge plasma capable of treating only an objective region on a substrate and complying with an enlarged treatment area with a simple means.
SOLUTION: In a method in which gas 2 for discharge and for treatment is supplied between two electrodes 1 to impress DC voltage, a surface treatment is conducted using the plasma with arc discharge generated between electrodes, the surface treatment is conducted by a method in which a plasma generating source is moved for a fixed substrate 3 or a method in which the plasma generating source is fixed and a substrate side is moved.



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CLAIMS

[Claim(s)]

[Claim 1] The surface-treatment approach by the DC arc discharge plasma characterized by to carry out surface treatment with the method to which it is the approach of carrying out surface treatment using the plasma by the arc discharge generated in this inter-electrode ones by supplying the object for discharge, and the gas for processing to inter-electrode [two], and impressing direct current voltage, and said plasma generation source is moved to the fixed substrate, or the method to which said plasma generation source is fixed to and a substrate side is moved.

[Claim 2] The surface treatment approach by the DC arc discharge plasma according to claim 1 characterized by installing two or more said plasma generation sources, and carrying out surface treatment.

[Claim 3] The surface treatment approach by the DC arc discharge plasma according to claim 1 or 2 characterized by moving said plasma generation source or substrate by program control.

[Claim 4] Claim 1 characterized by carrying out surface treatment of the field of arbitration by changing the relative position of said substrate and plasma generation source, or choosing and energizing either among two or more plasma generation sources thru/or the surface treatment approach according to the DC arc discharge plasma given in any 1 term among 3.

[Claim 5] It TEGa(s). as said object for discharge, and the gas for processing -- SiH_4, $SiCl_4$, and SI2 -- Cl6, CH_4, and C_3H_8 -- Claim 1 characterized by using gas, such as $TiCl_4$, NH_3, N_2, BF_3, O_2, CF_4, C_2F_6, Cu (DPM)2 and PH_3, C_3F_8, C_4F_8, and F_2, NF_3, Ar, helium, thru/or the surface treatment approach according to the DC arc discharge plasma given in any 1 term among 4.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the solid-state surface treatment technique in which the plasma was used, and relates to the approach of carrying out surface treatment by the arc discharge plasma by impressing direct current voltage to inter-electrode [two] in more detail.
[0002]
[Description of the Prior Art] Conventionally, the approach (plasma-CVD method) by the plasma using the RF glow discharge of an parallel monotonous mold as solid-state surface treatment techniques (a high speed, a continuation manufacturing technology, etc. of a large area amorphous-silicon solar cell) using the plasma is adopted. As that outline is shown in drawing 9 , this approach between the electrode 12 of the parallel monotonous mold of the pair which carried out opposite installation mutually into the container 11 in which evacuation is possible, and 13 By supplying mixed gas with the gas for processing, and other gas, impressing high-frequency voltage to this inter-electrode one with a power source 15, and making inter-electrode into the plasma state It is the technique of decomposing a part of gas, making a decomposition product acting on the substrate 16 attached in one electrode 13, and acquiring effectiveness, such as thin film deposition, etching, and surface treatment. In addition, 14 is an adjustment machine for taking adjustment of the impedance of a power source 15, and the impedance of the electrodes 12 and 13 of the parallel monotonous mold accompanied by the plasma. As a frequency of high-frequency voltage, 13.56MHz is used widely.
[0003] Three points indicated below are gained as a description of the solid-state surface treatment technique using the above-mentioned plasma.
** Large-area-izing of processing area is easily possible by enlarging area of the electrode of an parallel monotonous mold.
** Don't be dependent on the conductivity of a substrate or a deposit by the RF to discharge not being maintained in direct current discharge, when a substrate and a deposit are insulating materials.
** Processing quality may improve by making the frequency of high-frequency voltage into a RF more, or making it a pulse (for example, in being an amorphous-silicon solar cell, photoelectric conversion efficiency improves).
[0004]
[Problem(s) to be Solved by the Invention] However, by the plasma-CVD method by the above-mentioned conventional RF glow discharge, when large area-ization of processing area was advanced, it became the same as the wavelength of the RF which die length of one side of an electrode uses, and the ununiformity occurred in the electric-field distribution in an electrode surface, uniform processing became impossible, and there was a problem that the same quality as the case of small area was not securable. When the higher frequency and higher pulse which can be improved in quality were used especially for this problem, it became remarkable, and there was a limitation in increase-ization of processing area.
[0005] This invention was made in order to solve the problem in large area-izing of the plasma CVD method by the RF glow discharge of such a conventional parallel monotonous mold, and when it can process only to the field made into the purpose on a substrate, it tends to propose the surface treatment approach by the DC arc discharge plasma which can fully respond also to large area-ization of processing area with a simple means.
[0006]
[Means for Solving the Problem] The surface treatment approach by the DC arc discharge plasma concerning this

invention It is a method using the plasma by the arc discharge generated in inter-electrode by impressing direct current voltage to inter-electrode [two]. The summary is the approach of carrying out surface treatment using the plasma by the arc discharge generated in this inter-electrode one by supplying the object for discharge, and the gas for processing to inter-electrode [two], and impressing direct current voltage. It is characterized by carrying out surface treatment with the method to which said plasma generation source is moved to the fixed substrate, or the method to which said plasma generation source is fixed to and a substrate side is moved. Moreover, install two or more said plasma generation sources, and they carry out surface treatment, move said plasma generation source or substrate by program control, the relative position of said substrate and plasma generation source is changed, or either is chosen and energized among two or more plasma generation sources. in addition, as said object for discharge, and gas for processing SiH4, SiCl4, and Si2 -- gas, such as Cl6, CH4, C3H8, TEGa, TiCl4, NH3, N2, BF3, O2 and CF4, C2F6, B-2s H6, Cu (DPM)2, and PH3, C3F8, C4F8, and F2, NF3, Ar, helium, can be used.

[0007] As for the electrode structure in this invention, it is desirable to use a hollow cylinder and its medial axis as an electrode, respectively, and the cylinder diameter has 1 desirablecm or less. It is ****** about an operation of thin film deposition, etching, surface treatment, etc. to the substrate which the plasma by arc discharge occurs in inter-electrode, the gas for processing is decomposed, and that decomposition product blows off from a cylindrical opening edge, and counters with an opening edge by impressing direct current voltage between this conductive hollow cylinder and its medial axis, and introducing mixed gas with the gas for processing, or other gas in a cylinder. Moreover, although discharge is not maintained in the direct current discharge of an parallel monotonous mold as a substrate is insulation, the electrode has been independent to the substrate processed in this invention, and there is no conductivity dependency of a substrate.

[0008]

[Embodiment of the Invention] The schematic diagram and drawing 2 which show the basic configuration of the surface treatment approach by the DC arc discharge plasma which drawing 1 requires for this invention are what illustrated the electrode structure in this invention method. The schematic diagram showing the electrode with which (a) carried out opposite arrangement of an anode plate and the cathode, the schematic diagram showing the electrode with which (b) combined cathode and the anode plate of a cylindrical shape, (c) shows the electrode which has arranged two or more electrodes of the structure shown in (b), and constituted them. The schematic diagram showing the electrode with which (d) consists of cathode and a multistage cylindrical shape anode plate, the schematic diagram showing the electrode which (e) has arranged to multistage the electrode which carried out opposite arrangement of an anode plate and the cathode, and was constituted, The schematic diagram showing an example [as opposed to a flexible polymer substrate in drawing 3] of the surface treatment approach, The schematic diagram showing an example of the approach drawing 4 performs double-width surface treatment on a sheet-like substrate, The schematic diagram showing an example of the approach of drawing 5 carrying out spacing arrangement of the electrode of two or more arrangement configuration shown in drawing 2 (c), and creating the thin film of three layers continuously, The schematic diagram showing an example of the approach drawing 6 performs surface treatment to the field of the arbitration on a substrate, The schematic diagram which illustrated how drawing 7 (a) and (b) create a microcrystal thin film on a substrate, respectively, Drawing 8 is the schematic diagram showing an example of the approach of forming a solar battery on a flexible polymer substrate. 1 -- an electrode and 1-1 -- an anode plate and 1-2 -- cathode and 2 -- the object for discharge and the gas for processing, and 3 -- for the diameter of opening of a nozzle, and L1, as for the distance at the tip of cathode, and the tip of an anode plate, and 3-1, the distance of a nozzle tip and a substrate and L2 are [a substrate and 4 / a field and W / a flexible polymer substrate and 3-2] sheet-like substrates.

[0009] In drawing 1 , if the object for discharge and the gas 2 for processing are supplied to the gap between an anode plate 1-1 and cathode 1-2, processing it is decided in the property of the gas for processing that will be the field 4 of a substrate 3 will be performed. In this case, the diameter of a field 4 is decided by the distance L1 of the diameter W of opening of a nozzle, a nozzle tip, and a substrate. Moreover, in case the distance L2 at the tip of cathode and the tip of an anode plate controls the effectiveness of heating accompanying the plasma exposure to a field 4, it is changed. If this distance L2 is enlarged, the heating effectiveness will be controlled, and the heating effectiveness will be promoted if it is made small. That is, if the source of the minute plasma using the direct current as electrode voltage is used, it can process to the field made into the purpose on a substrate.

[0010] Next, drawing 2 (a) is the example which carried out horizontal arrangement of the electrode, and the high voltage is impressed to the electrode 1 which carried out opposite arrangement and constituted an anode plate 1-1 and

cathode 1-2. Surface treatment of only the plasma exposure section on a substrate 3 can be performed by passing Ar gas from end face of the one of the two in the gap between an anode plate 1-1 and cathode 1-2, making it the plasma state, and already irradiating chemical species [labile / in the plasma] from the nozzle of one of the two's end face at a substrate 3. (b) is the example which carried out vertical arrangement of the electrode, and impresses the high voltage to anode plate 1-1' of cathode 1-2 and a hollow cylinder form. In the gap of cathode 1-2 and anode plate 1-1' of a hollow cylinder form, pass CF4, C3F8, C2F6, C4F8, F2, and NF3 grade, and it is made the plasma state in it. By irradiating labile chemical species for example, on the Si substrate 3 from the outlet of a hollow cylinder, only the plasma exposure section on the Si base 3 can be etched. moreover, the substrate 3 top which counters by putting two or more electrodes 1 in a row to a single tier, and using O2 as discharge gas as shown in (c) -- a line -- it can process. Furthermore, when the electrode 1 which consists of cathode 1-2 and multistage hollow cylinder form anode plate 1-1' as shown in (d) is used, or when the electrode 1 which carried out opposite arrangement of an anode plate 1-1 and the cathode (1-2) as shown in (e) is arranged and constituted in multistage By controlling the bias voltage of each stage, control which is extent by which the plasma is direct made substrate 3 front face which processes by controlling the configuration of the plasma emitted from an outlet can be performed.
[0011] Drawing 3 can carry out surface treatment of the front face of the flexible polymer substrate 3-1 wound around the roll continuously covering predetermined width of face by irradiating Ar plasma using the electrode 1 of the structure shown in drawing 2 (c) to the flexible polymer substrate 3-1 conveyed with Roll R.
[0012] Drawing 4 is what illustrated the approach of following the sheet-like substrate 3-2 and performing surface treatment, such as thin film deposition, and it can perform surface treatment, such as thin film deposition, continuously by installing an electrode 1 above a substrate 3-2 in this case at a single tier, and moving a substrate 3-2 in said electrode train and the right-angled direction, without being disrupted on this substrate 3-2. In this case, since electron density of an electrode 1 can be made into the high density plasma from the conventional source of the parallel monotonous mold plasma, high processing speed is obtained. Furthermore, although an ununiformity will arise within a train under the effect of wavelength in the source of the plasma using the conventional RF if the die length of the single tier of an electrode becomes long, the effect does not exist at this invention using direct current discharge.
[0013] Drawing 5 is what illustrated the approach of forming multilayers above the flexible polymer substrate 3-1 conveyed with Roll R. In this case, keep spacing of a request of the electrode 1 installed in the single tier shown in drawing 4 side by side in the conveyance direction, for example, three trains are installed. Membranes can be continuously formed by generating the plasma which used the SiH4/SiH4/PH3 mixture-of-gas, SiH4, and B-2H6 mixture of gas for each electrode train, without disrupting Si diaphragm structure, p mold, i mold, and n mold, of three layers.
[0014] Drawing 6 is what illustrated the art of the arbitration configuration field by the single electrode, and an electrode 1 and a substrate 3 are movable in the cross direction, the die-length direction, and the height direction by the horizontal migration device and the vertical migration device respectively. Therefore, in the case of this method, surface treatment can be performed to the field of the arbitration on a substrate 3 according to the horizontal migration device of an electrode 1 and a substrate 3. Moreover, if it is extent of surface preparation, i.e., a thin film, and is etching about the rate of sedimentation or thickness, an etching rate or the etching depth is controllable by the vertical migration device of an electrode 1 and a substrate 3. The electrode and substrate in this approach are moved by program control.
[0015] Drawing 7 (a) and (b) are the approaches of introducing reactant gas SiH4 or SiF4 to discharge gas H2, and the shape of an atom H generated in the plasma decomposing reactant gas using the electrode shown in drawing 2 (a) and (b), and making a microcrystal Si thin film depositing on sheet-like 2 [substrate 3-] at low temperature 300 degrees C or less by contribution of a lot of H radicals, respectively. According to this approach, the volume of the polycrystalline silicon thin film can be carried out by using the substrate temperature of 400 degrees C or more. Moreover, the large area membrane formation of the polycrystalline silicon thin film can be continuously carried out on a flexible polymer substrate by using a continuation membrane formation method using the flexible polymer substrate which has the super-thermal resistance of 400 degrees C or more.
[0016] Moreover, as shown in drawing 8 , by adding a lamination process, on the flexible polymer substrate 3-1, a metal-electrode formation fault is efficient and a transparent electrode formation fault can form a polycrystal silicon solar cell at the continuation deposition of p layers, i layers, and n layers using the polycrystalline silicon to the above-mentioned flexible polymer substrate 3-1 top.

[0017] In addition, it is possible to perform processing indicated below.
(1) Use TiCl4, N2, and NH3 for the source of the plasma as gas, and perform TiN coating for the source of the plasma itself, and the object to irradiate to the object of an arbitration configuration X, Y, and by carrying out X five axis control by computer control.
(2) Carry out extensive processing of the diamond coating continuously by using CH4 of H2 dilution as gas to many cutting cutting tools who arranged on the tray.
(3) Form the high printed circuit board of adhesion by the large area, the high speed, and continuation by arranging an electrode two trains, establishing the source of the plasma of Ar or helium in the front row, raising the adhesion on the front face of a substrate, and establishing the copper thin film formation plasma which used Cu content gas raw material of Cu(DPM)2 grade for the back row as a raw material.
(4) N atom generated in high density N2 plasma by turns in the electrode and the cylinder in the air by passing TEGa to a hollow cylinder and passing N2 in a sink and a discharge cylinder in a bundle in the shape of a cylinder reacts with TEGa, and form GaN on a substrate. Moreover, since atmospheric-pressure discharge is possible, it is expected that growth speed will be early and bulk growth is also predicted to be possible.
In (5) and (4), SiC is grown up on a substrate by using all as a discharge cylinder and bundling the cylinder using Si content gas of SiCl4 and Si2Cl6 grade, and C content gas of CH4 or C3H8 grade as discharge gas in the shape of a cylinder by turns.
[0018]
[Effect of the Invention] By having used the plasma by the arc discharge generated in inter-electrode by impressing direct current voltage to inter-electrode [two] according to this invention, as explained above High processing speed is obtained by improvement in electron density compared with the direct-current-discharge method of the conventional parallel monotonous mold, and in being thin film deposition Since the deposition speed of a membrane formation element improves relatively to the speed which the impurity in the container which forms membranes mixes into the film, the impurity consistency within the thin film finally obtained is reduced, and upgrading is measured. Furthermore, while being able to perform large area-ized processing easily by putting many cylindrical shape electrodes in order continuously, large area membrane formation of high quality is securable. Moreover, if a RF is used and said cylinder queue length will approach wavelength, that effect is avoidable also at this time, by having used the direct current to the same effect as an parallel plate appearing. Moreover, by this invention method, thin film deposition is attained to the field of arbitration by changing the relative position of a substrate and a nozzle to large-area-izing and coincidence, or turning on a nozzle and carrying out OFF control.

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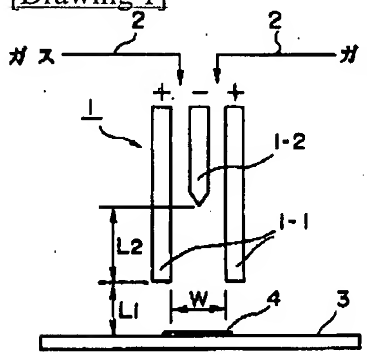
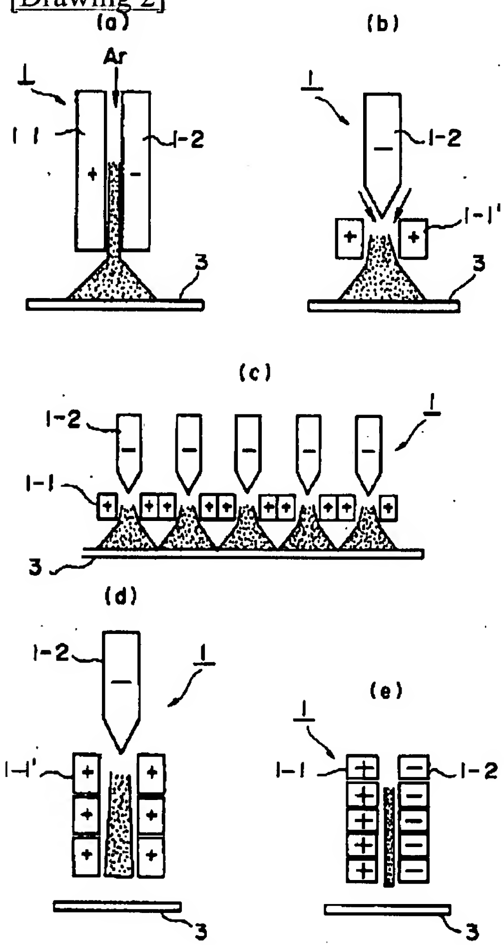
DRAWINGS

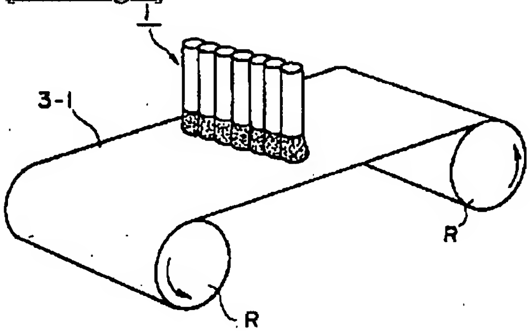
[Drawing 1]



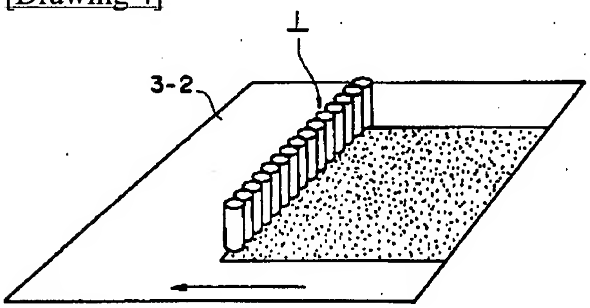
[Drawing 2]



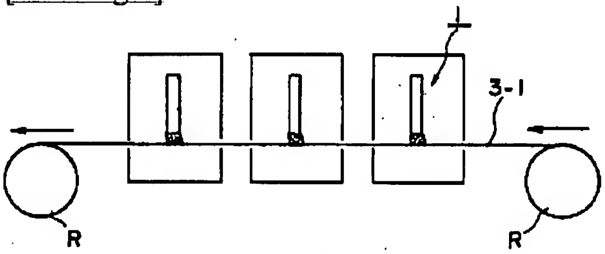
[Drawing 3]



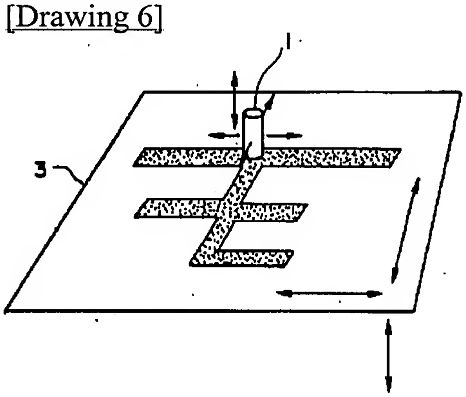
[Drawing 4]



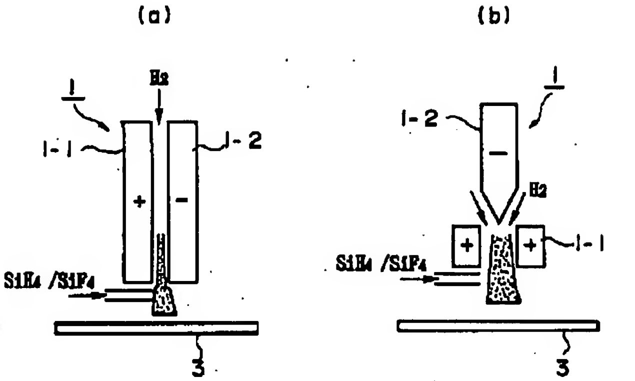
[Drawing 5]



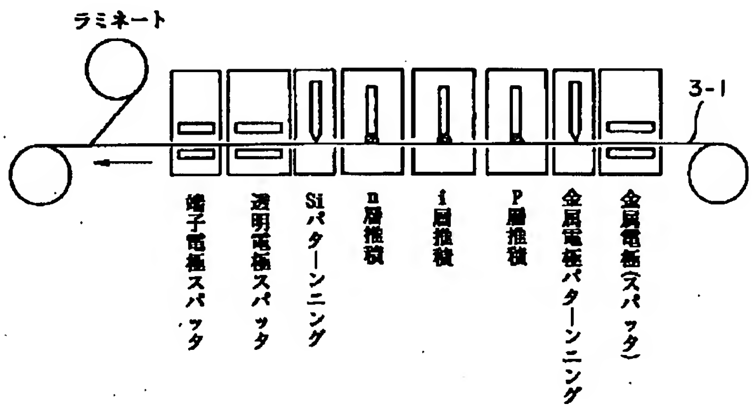
[Drawing 6]



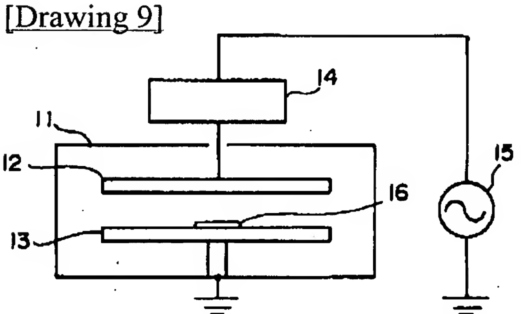
[Drawing 7]



[Drawing 8]



[Drawing 9]



[Translation done.]

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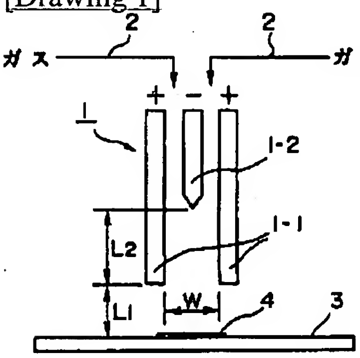
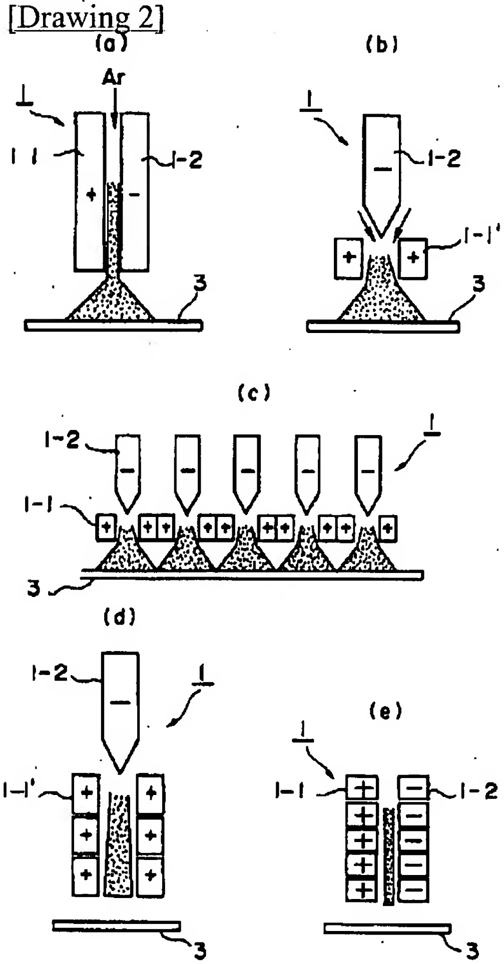
3.In the drawings, any words are not translated.

DRAWINGS

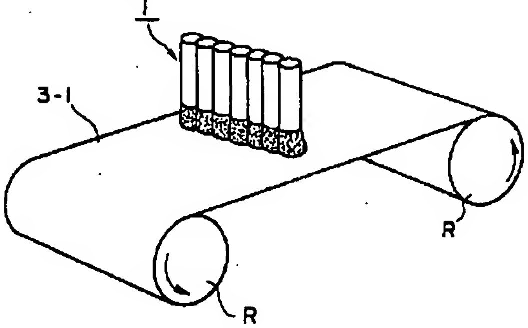
[Drawing 1]



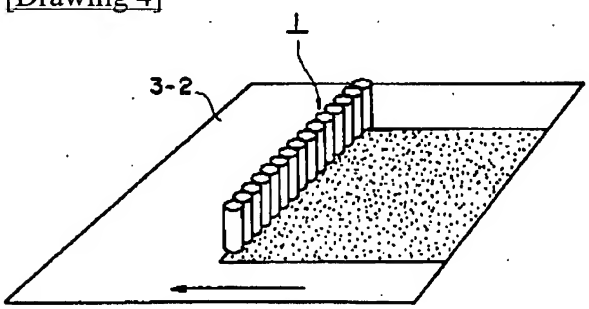
[Drawing 2]



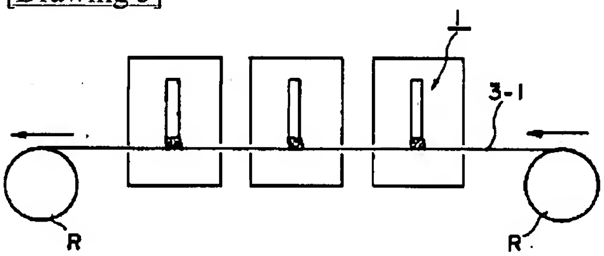
[Drawing 3]



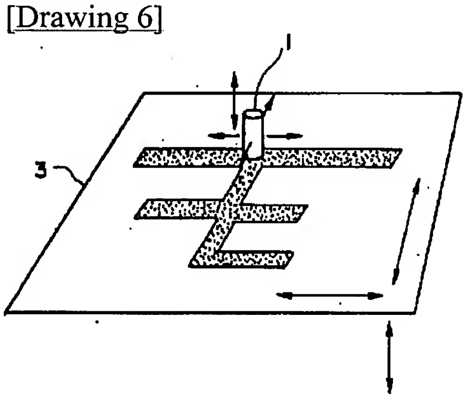
[Drawing 4]



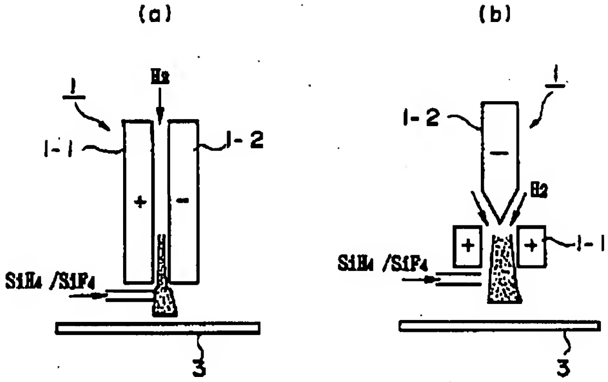
[Drawing 5]



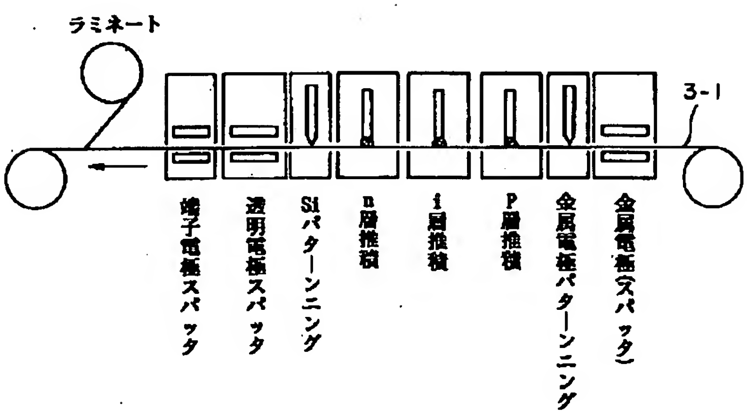
[Drawing 6]



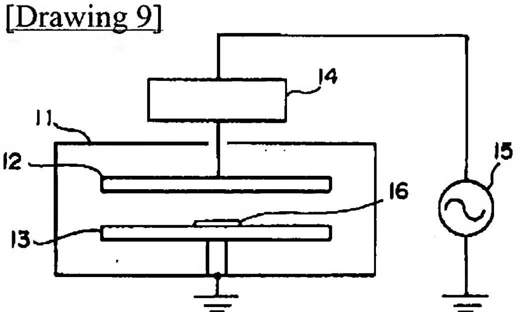
[Drawing 7]



[Drawing 8]



[Drawing 9]



[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the schematic diagram showing the basic configuration of the surface treatment approach by the DC arc discharge plasma concerning this invention.
[Drawing 2] The schematic diagram showing the electrode with which it is what illustrated the electrode structure in this invention method, and (a) carried out opposite arrangement of an anode plate and the cathode, The schematic diagram showing the electrode with which (b) combined cathode and the anode plate of a cylindrical shape, the schematic diagram showing the electrode which (c) has arranged two or more electrodes of the structure shown in (b), and was constituted, They are the schematic diagram showing the electrode with which (d) consists of cathode and a multistage cylindrical shape anode plate, and the schematic diagram showing the electrode which (e) has arranged to multistage the electrode which carried out opposite arrangement of an anode plate and the cathode, and was constituted.

[Drawing 3] It is the schematic diagram showing an example of the surface treatment approach to a flexible polymer substrate.
[Drawing 4] It is the schematic diagram showing an example of an approach which performs double-width surface treatment on a sheet-like substrate.
[Drawing 5] It is the schematic diagram showing an example of the approach of carrying out spacing arrangement of the electrode of two or more arrangement configuration shown in drawing 2 (c), and creating the thin film of three layers continuously.
[Drawing 6] It is the schematic diagram showing an example of an approach which performs surface treatment to the field of the arbitration on a substrate.
[Drawing 7] It is what illustrated the approach of creating a microcrystal thin film on a substrate, and a schematic diagram when (a) uses the electrode shown in drawing 2 (a), and (b) are the schematic diagrams at the time of using the electrode shown in drawing 2 (b).
[Drawing 8] It is the schematic diagram showing an example of the approach of forming a solar battery on a flexible polymer substrate.
[Drawing 9] It is the schematic diagram showing the conventional approach (plasma-CVD method) by the plasma using the RF glow discharge of an parallel monotonous mold.
[Description of Notations]
1 Electrode
1-1 Anode Plate
1-2 Cathode
2 Object for Discharge, and Gas for Processing
3 Substrate
4 Field
W The diameter of opening of a nozzle
L1 Distance of a nozzle tip and a substrate
L2 Distance at the tip of cathode, and the tip of an anode plate
3-1 Flexible Polymer Substrate
3-2 Sheet-like Substrate

[Translation done.]